# Modeling the Impact of a Carbon Tax on the Commercial Building Sector

PRESENTED AT THE 2012 ACEEE SUMMER STUDY ON EFFICIENCY IN BUILDINGS

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# Why a Carbon Tax?

- Climate change is an unintended consequence of burning fossil fuels
  - "Climate change is the greatest and widest-ranging market failure ever seen." (Stern, 2007)
- A Pigouvian tax is an economically efficient means of addressing an externality

| Political Feasibility | Economic Desirability* | | |
|---|---|---|---|
| | **High** | **Medium** | **Low** |
| **High** | | | Renewable portfolio standards (29) |
| **Medium** | Cap and trade (13-23) | | |
| **Low** | Carbon tax (0) | | |

*Numbers in parentheses indicate the number of states that have adopted each regulatory approach.

# Interest in a Carbon Tax Remains

- The Managed Carbon Price Act of 2012
- Brookings Reports
- Australian Carbon Tax
- Citizens Climate Lobby, AEI, Climate Crisis Coalition
- Numerous ongoing local efforts
  - Vancouver/British Columbia
  - Babylon NY

# Research Question and Methods

- What would the impact of an efficient carbon tax be on the commercial building sector?
- Utilize GT-NEMS 2011
  - Derived from AEO 2011 NEMS
  - Models ~350 technologies in 10 end uses across 11 building types and 9 census divisions
- Institute $CO_2$ tax in 2015
  - Cost schedules vary; main scenario starts at $25/metric ton and increases at 5% annually
- Enable High Tech Equipment Menu
  - Lower cost, higher efficiency, earlier availability
  - Used by a subset of scenarios

# Benefits and Limitations of GT-NEMS

- Advantages
  - Detailed characterization of technologies, end-uses, building types, geography, and investments
  - Integrated solution shows interactions with price and other sectors, up to the macro-economy
- Disadvantages
  - Lack of holistic building design and operations perspective
  - Building shell simplicity
  - Elevated consumer discount rates
  - Limited revenue recycling options
  - 25-year time frame

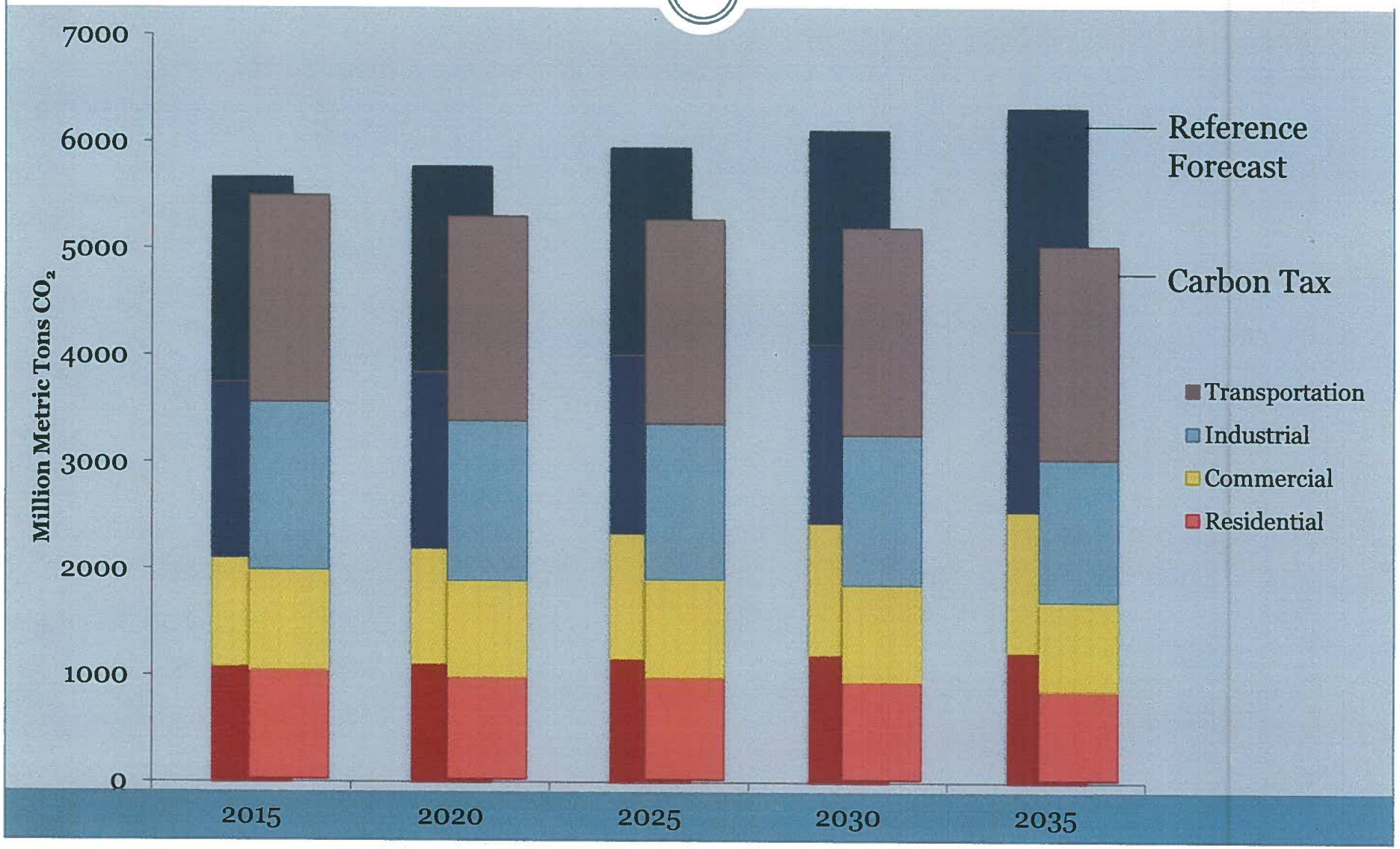
# Scenarios

- Main Tax Scenario:
  - An economy-wide tax on $CO_2$ emissions, starting from $25/ton of $CO_2$, increasing 5% annually
- Low-tax Scenario:
  - $5 per metric ton of $CO_2$, increasing 5% annually
- Social Cost of Carbon (SCC) Moderate-tax Scenario:
  - Based on the SCC estimates calculated with a 3% discount rate (EPA, 2010)
- SCC High-tax Scenario:
  - Based on the SCC estimates calculated with a 2.5% discount rate
- EIA GHG Scenario:
  - The *AEO 2011* GHG Price Economy-wide Case (EIA, 2011)
- Best Tech Scenario:
  - Follows the EIA best-tech case, where the most efficient technology is always selected; intended as a low bound

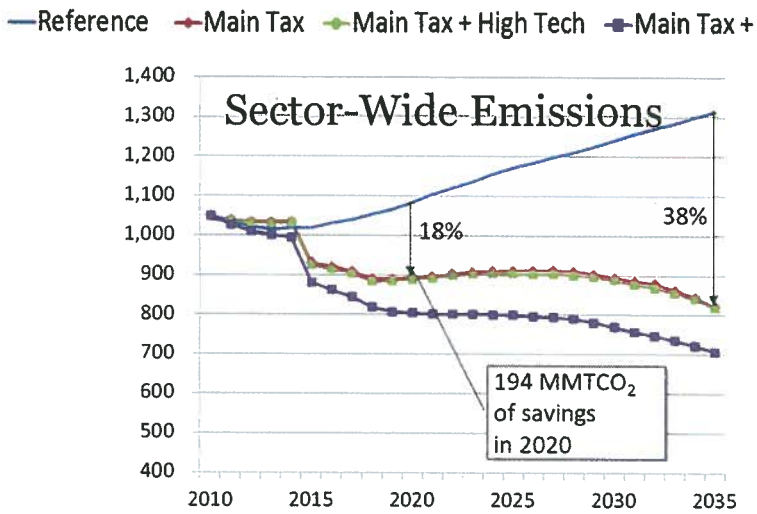
# Carbon Tax Schedules (2009-$/MTCO$_2$)

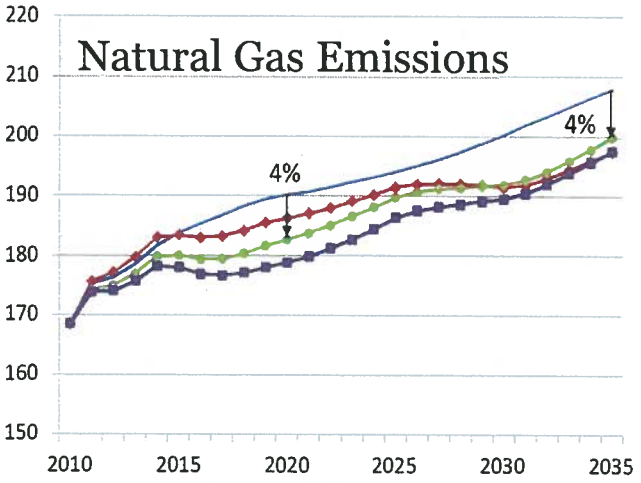
| | Low | SCC Moderate | Main Tax Scenario | SCC High | EIA GHG |
|---|---|---|---|---|---|
| 2015 | 5 | 23.3 | ***25*** | 39.7 | 27.6 |
| 2020 | 7.8 | 25.8 | ***31.9*** | 43.2 | 35.5 |
| 2025 | 9.0 | 28.7 | ***40.7*** | 47.3 | 45.5 |
| 2030 | 10.5 | 32.1 | ***52.0*** | 51.7 | 58.4 |
| 2035 | 12.1 | 35.5 | ***66.3*** | 56.1 | 75 |

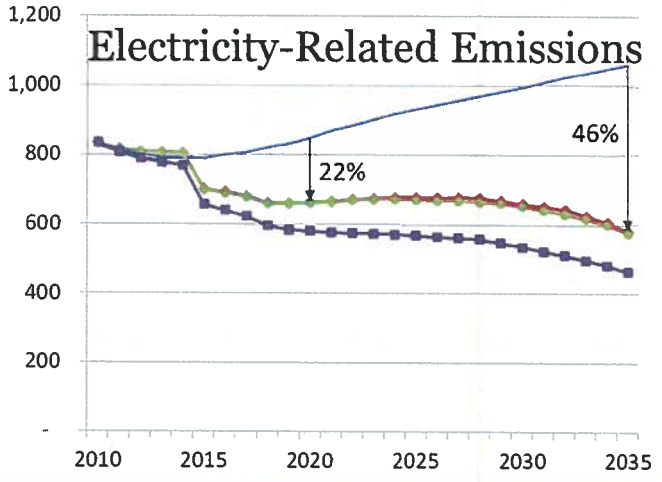
# Results: National $CO_2$ Emissions Decline



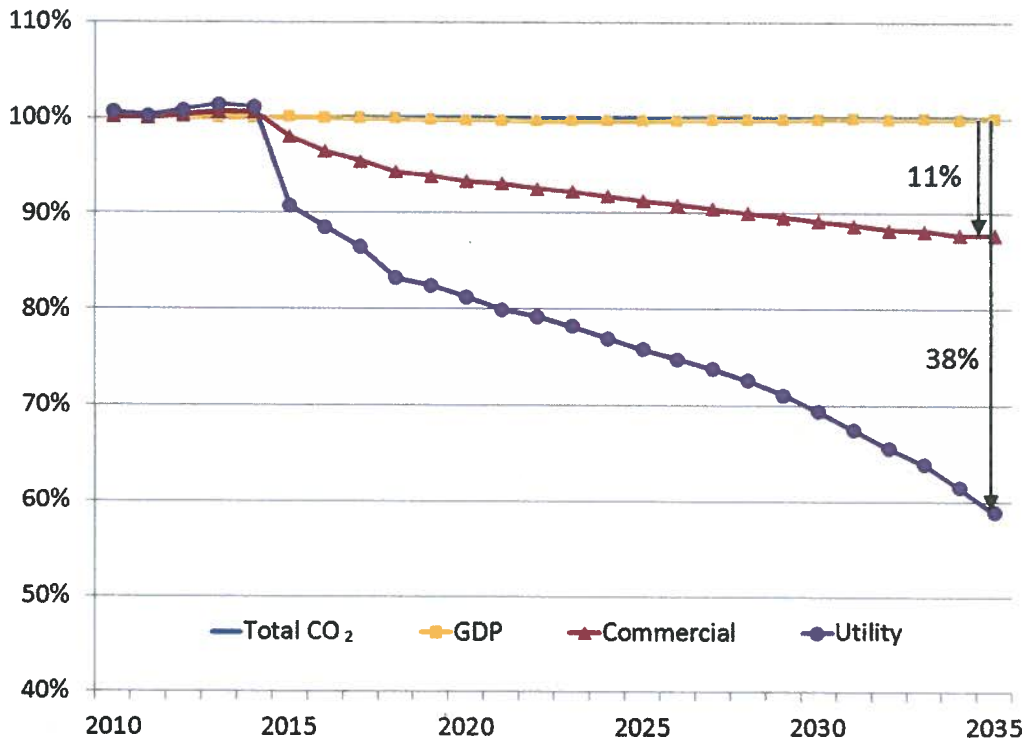
# Commercial Sector $CO_2$ Emissions are Cut by More Than a Third



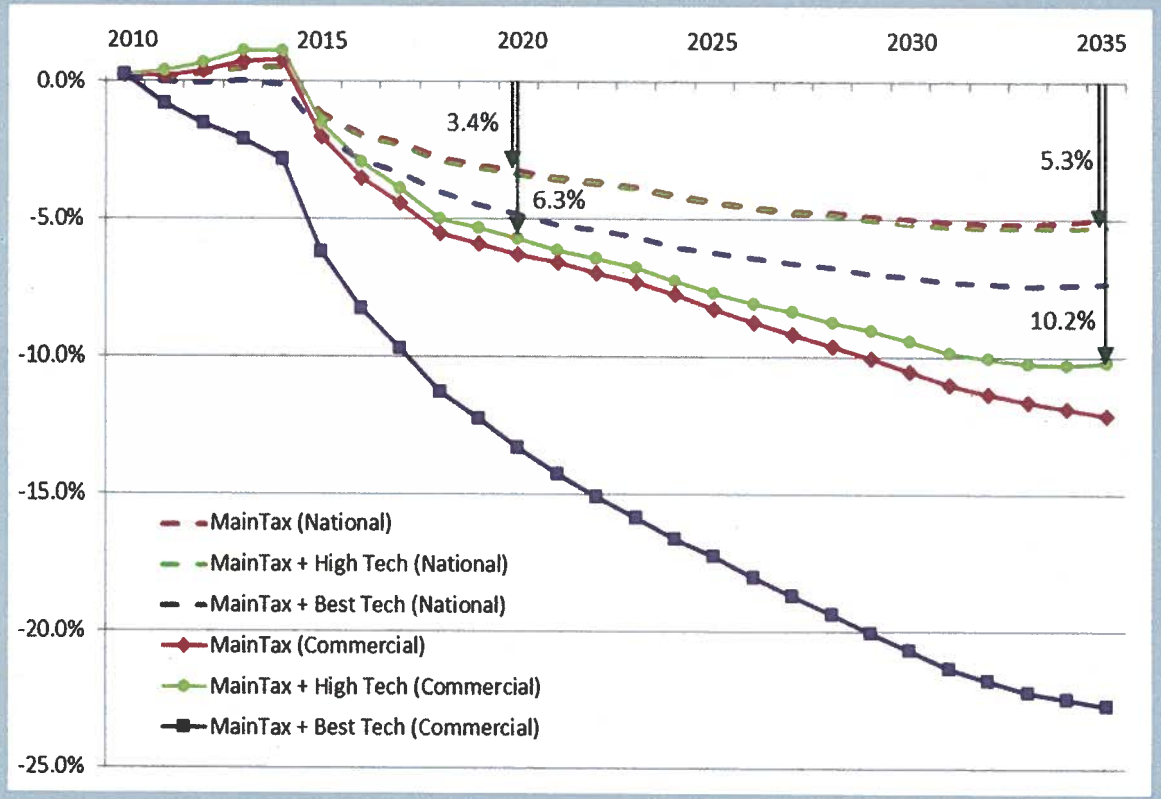



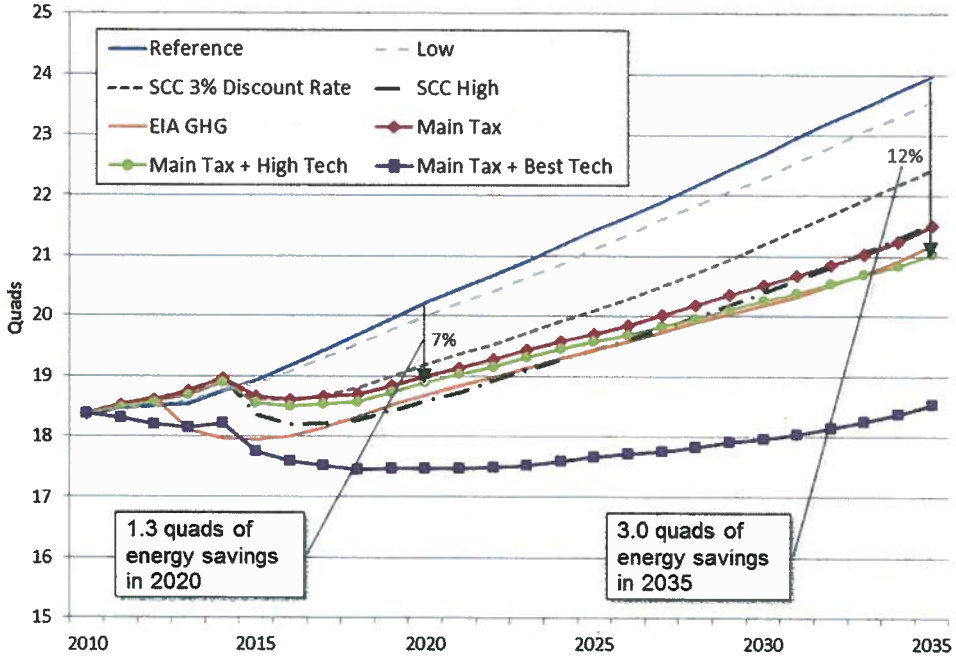
# The Bulk of $CO_2$ Reductions Come From Changes in Utility Generation Mix



# Energy Intensity Declines Fastest in the Commercial Sector

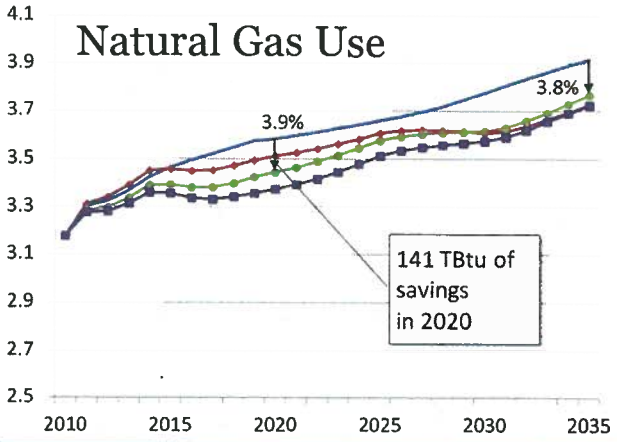


# Commercial Energy Consumption Decreases 12% in 2035 in the Main Tax + High Tech Scenario

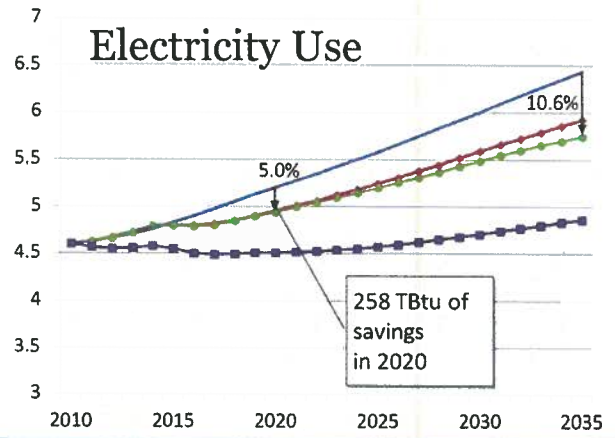



## Sector-Wide Energy Use

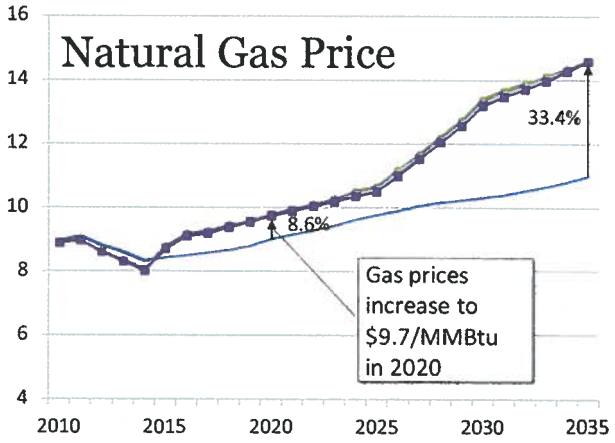
### Natural Gas Use

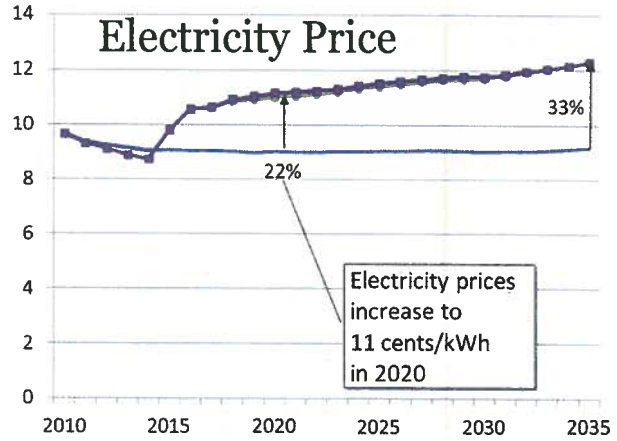


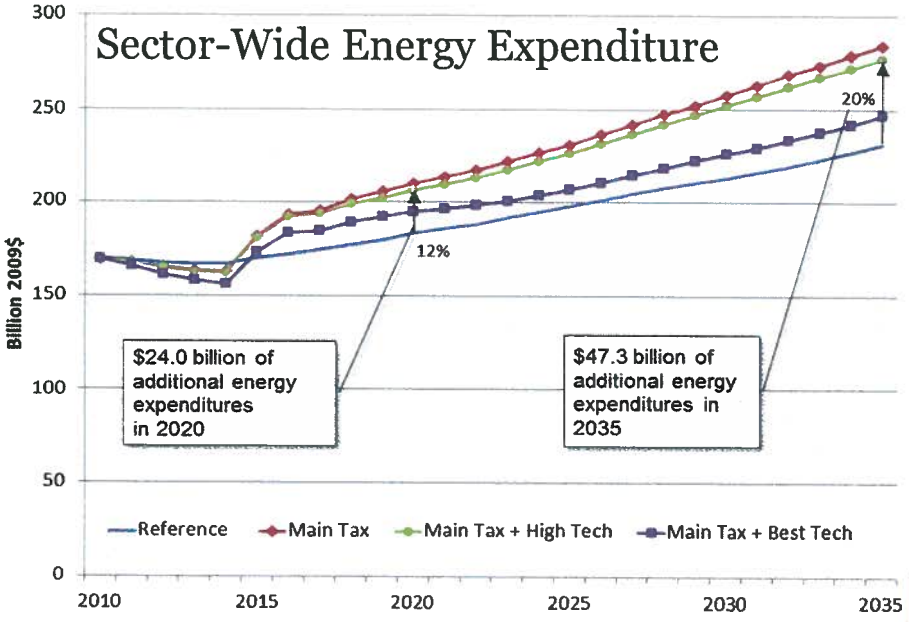

### Electricity Use



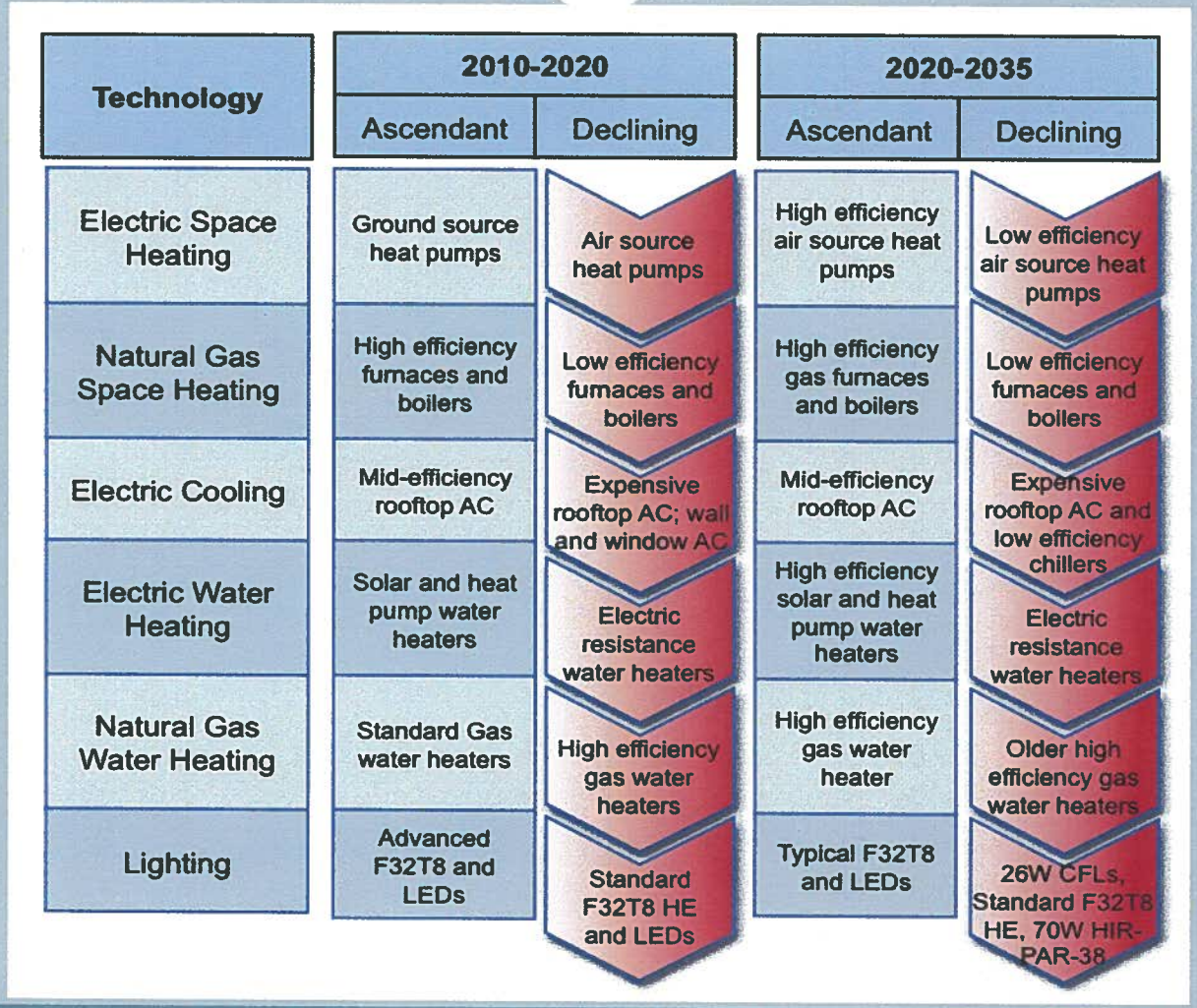
# The Tax Drives Prices Higher



# Significant Improvements in the Selection of Efficient Equipment



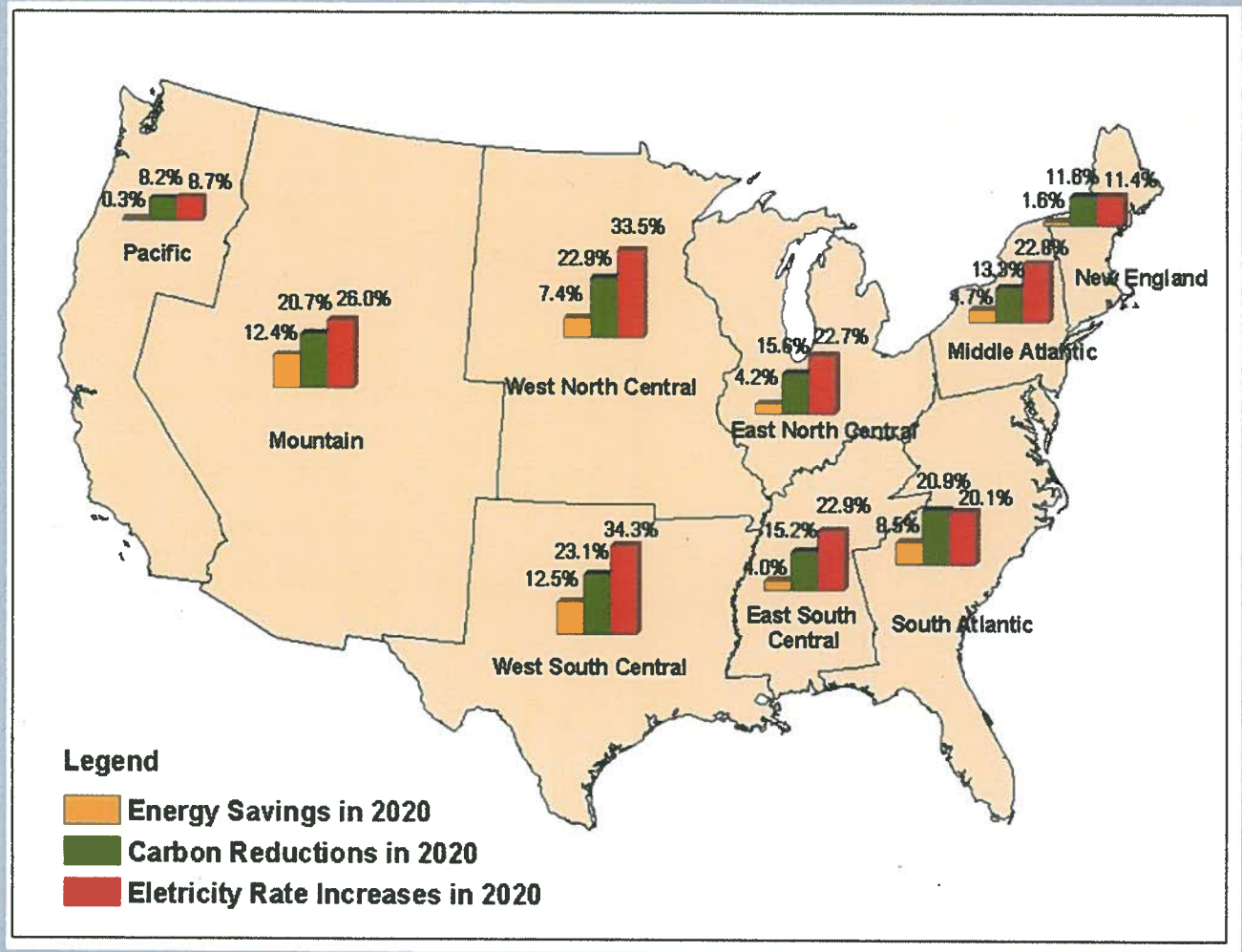
| Technology | 2010-2020 | | 2020-2035 | |
|---|---|---|---|---|
| | Ascendant | Declining | Ascendant | Declining |
| Electric Space Heating | Ground source heat pumps | Air source heat pumps | High efficiency air source heat pumps | Low efficiency air source heat pumps |
| Natural Gas Space Heating | High efficiency furnaces and boilers | Low efficiency furnaces and boilers | High efficiency gas furnaces and boilers | Low efficiency furnaces and boilers |
| Electric Cooling | Mid-efficiency rooftop AC | Expensive rooftop AC; wall and window AC | Mid-efficiency rooftop AC | Expensive rooftop AC and low efficiency chillers |
| Electric Water Heating | Solar and heat pump water heaters | Electric resistance water heaters | High efficiency solar and heat pump water heaters | Electric resistance water heaters |
| Natural Gas Water Heating | Standard Gas water heaters | High efficiency gas water heaters | High efficiency gas water heater | Older high efficiency gas water heaters |
| Lighting | Advanced F32T8 and LEDs | Standard F32T8 HE and LEDs | Typical F32T8 and LEDs | 26W CFLs, Standard F32T8 HE, 70W HIR-PAR-38 |

# Expanded Investment in Efficient Technologies Increases Equipment Expenditures

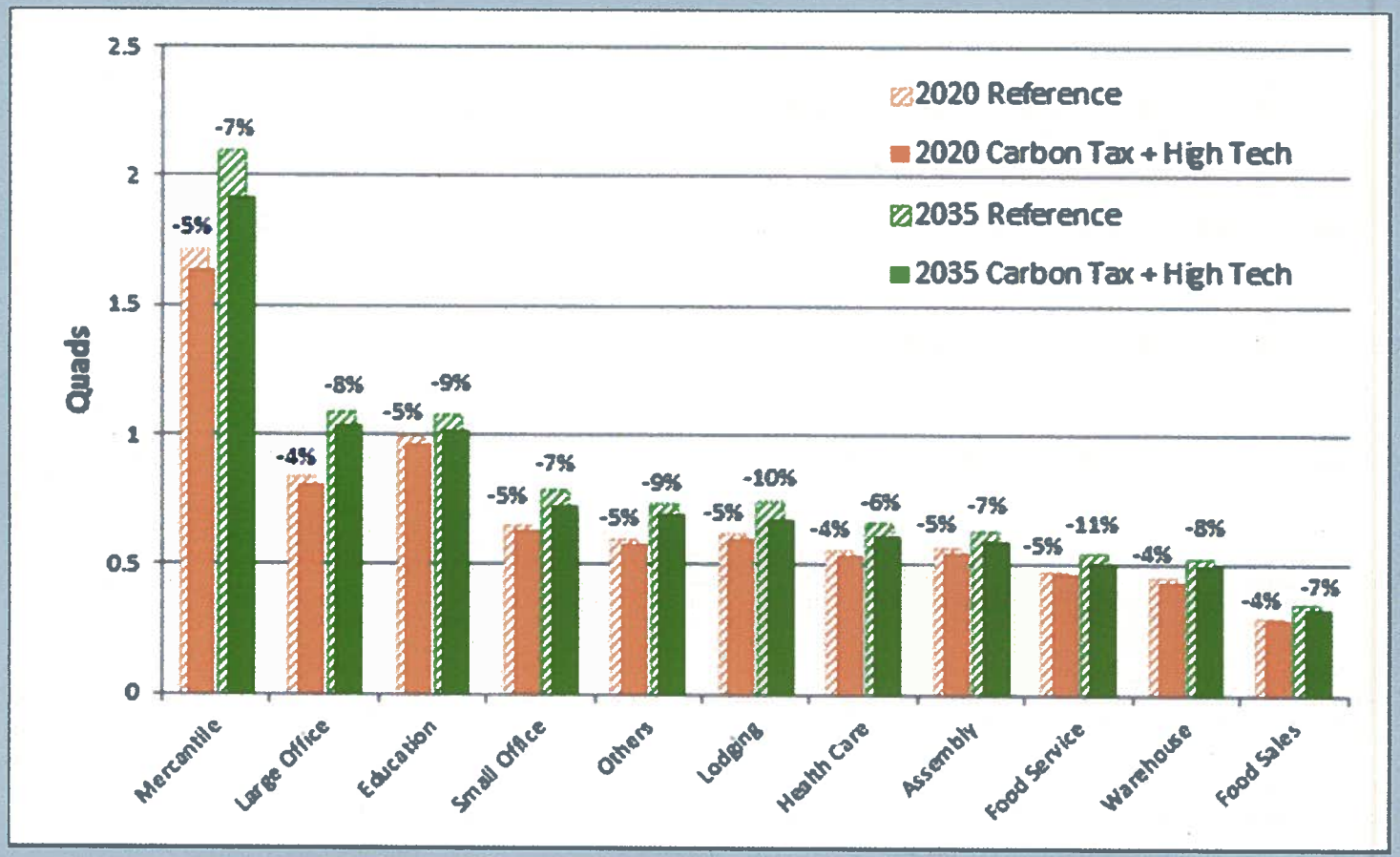
| Year | Total in Reference Case | Total in Main Tax + High Tech Scenario | Incremental Investment Cost: Annual | Incremental Investment Cost: Cumulative* |
|---|---|---|---|---|
| **2020** | 67.1 | 75.5 | 8.4 (12.5%) | 69 |
| **2035** | 79.1 | 89.5 | 10.4 (13.1%) | 162 |

*Present values were calculated using a 3% discount rate. All values in Billions 2009-$.

# Energy Savings are Lower than Carbon Reductions for All Regions



# Energy Savings in Buildings Scale According to the Energy Intensity of Operations



# Main Tax + High Tech Case Would Delay the National GDP by at Most 3.1 Days

| Scenario | GDP (Billion 2009-$) | 2015 | 2020 | 2035 |
|---|---|---|---|---|
| **Reference** | GDP | 16,850 | 19,140 | 28,220 |
| **Main Tax** | GDP | 16,790 | 18,970 | 28,130 |
| | Change* | -0.33% | -0.86% | -0.32% |
| | ***Delay (day)*** | ***1.2*** | ***3.1*** | ***1.2*** |
| **Main Tax + High Tech** | GDP | 16,790 | 18,970 | 28,120 |
| | Change* | -0.36% | -0.86% | -0.34% |
| | ***Delay (day)*** | ***1.2*** | ***3.1*** | ***1.2*** |

*Numbers are percentage change relative to the Reference case

**"Delay" in GDP growth is defined as the number of days in a year required to make up the difference between GDP in the Reference case versus GDP in the carbon tax policy scenarios.

# Additional Emissions Benefits Are Potentially Worth Billions

| Year | Value of Avoided $CO_2$: Annual | Value of Avoided $CO_2$: Cumulative** |
|---|---|---|
| **2020** | 5 | 23 |
| **2035** | 19 | 187 |
| **Total Impact** | | 363 |

This corresponds to an 18% drop in commercial sector emissions

| Year | Value of Avoided $SO_2$: Annual | Value of Avoided $SO_2$: Cumulative* | Value of Avoided $NO_x$: Annual | Value of Avoided $NO_x$: Cumulative* | Value of Avoided PM: Annual* | Value of Avoided PM: Cumulative** |
|---|---|---|---|---|---|---|
| **2020** | 5.4 | 22 | 0.4 | 1.7 | 0.4 | 1.6 |
| **2035** | 9.3 | 133 | 0.7 | 9.3 | 0.7 | 9.0 |
| **Total Impact** | | 205 | | 14.6 | | 14.2 |

* Both $PM_{10}$ and $PM_{2.5}$ are included

**Present values were calculated using a 3% discount rate.

Estimates do not include various non-monetized values (e.g. mercury pollution reduction, increased productivity, water quality impacts, etc.). All values in billions of 2009-$.

# Benefits of the Tax Offset the Costs if Tax Revenues are Rebated to Citizens

| | Cumulative Social Benefits (Billions $2009) | | | | Cumulative Social Costs (Billions $2009) | | | Benefit/Cost Analysis | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Tax Rebates | Value of Avoided $CO_2$ | Value of Avoided Criteria Pollutants | Total Social Benefits | New Equipment Expenditures | Energy Expenditures | Total Social Costs** | Social B/C Ratio | Net Societal Benefits (Billions $2009) |
| 2020 | 152.9 | 22.5 | 30.8 | 206.2 | 155.9 | 109.7 | 265.5 | | |
| 2035 | 788.3 | 187.0 | 237.5 | 1212.8 | 452.5 | 643.4 | 1095.9 | | |
| Total Impact | 788.3 | 362.8 | 437.6 | 1588.7 | 452.5 | 1092.3 | 1544.9 | 1.0 | 44 |

# Conclusions

- The commercial sector is more responsive to a carbon tax than other demand sectors of the economy
- A carbon tax slows the projected growth in $CO_2$ and energy consumption
  - 18% decline in commercial $CO_2$ emissions contribute to a 10% decline in national $CO_2$ emissions in 2020
  - A 38% decline in commercial emissions contributes to the 22% decline in 2035
  - 7% reduction in commercial energy consumption in 2020; 12% by 2035
- A high level of associated emissions benefits couple with higher energy and equipment expenditures
- GDP grows slightly slower, recovering in a few days
- The carbon tax analyzed misses Better Buildings and Copenhagen goals

# Next Steps: Analyzing an Integrated Carbon and Energy Policy Portfolio

- Overcoming Information Gaps through Energy Benchmarking
- Implementing Aggressive Commercial Building Codes
- Making Buildings Part of the Climate Solution with Flexible Innovative Financing
- Integration of all four

# For More Information*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# Back ups


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# Sources of Electricity Generation